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PRELIMINARY RESULTS OF INVESTIGATION OF METEOR MATTER ALONG THE FLIGHT TRAJECTORY OF THE "MARS-1" PROBE

by

T. N. Nazarova
A. K. Bektabegov
O. D. Komissarov

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PRELIMINARY RESULTS OF INVESTIGATION OF METEOR MATTER ALONG THE FLIGHT TRAJECTORY OF THE " MARS-1 " PROBE *

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by T. N. Nazarova,
A. K. Bektabegov
O. D. Komissarov

ABSTRACT

This investigation was conducted with the aid of piezometric sensors. The area sensitive to meteoric particle impacts constituted 1.5 m^2.

The probe crossed the meteor stream Taurides on November 1st 1962. The mean frequency of meteor particle impacts against the sensitive surface during the session, at a distance from 6600 to 42 000 km constituted $7 \cdot 10^{-3}\ m^{-2}\ sec^{-1}$. The spatial density of meteor bodies in the stream is extremely irregular. Between December 31, 1962 and January 30, 1963 the probe met again with a meteor stream at distances between 23 and 45 000,000 km from the Earth. So far it could not be identified with any well-known on Earth meteor stream.

The mean spatial density of par icles and the distribution of matter in the stream make it comparable with Taurides. The mean impact frequency constituted $4.5 \cdot 10^{-3}\ m^{-2}\ sec^{-1}$.

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* PREDVARITEL'NYYE REZUL'TATY ISSLEDOVANIYA METEORNOGO VESHCHESTVA VDOL' TRAYEKTORII POLETA MEZHLANETNOY STANTSII " MARS-1 ".

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* also presented at IVth Cospar Space Science Symposium, Warsaw, June 1963

Only informations on the nature and distribution of meteoric particles near the ecliptic plane and within Earth orbit limits have been until very recently obtained on the basis of study of meteor matter by means of rockets and satellites. The flight of the "MARS-1" probe provided the first possibility of investigating the meteor matter beyond the Earth's orbit, at great distances from the Sun.

The registration of meteor particle impacts aboard the "MARS-1" probe was conducted with the help of piezometric sensors disposed at the rear side of solar batteries. Signals from pickups were fed to a transformer-amplifier assuring the resonance amplification of signals, the memorizing of the number of impacts in trigger elements and the telemetring of the thus memorized information from each element of the memory circuit. The counting of impacts started with two. The time of impact accumulation was two minutes. Thus, in the case when there was more than two minutes of time between cycles in which impacts were registered, the count might have been $N-1$ or N, and in the time interval, when there was no impact registration, there could have been no more than one. The area sensitive to meteor particle impacts constituted $1.5\ m^2$.

The characteristic of sensor sensitivity is plotted in Fig. 1. As may be seen, the sensitivity maximum corresponds to a small area situated directly above the sensor. In the zone of ~ 40 cm surrounding the sensor, the sensitivity varies insignificantly: it does not exceed ± 3 db. The area of this zone was specifically used in the computations when determining the density of meteor matter. The scientific instrumentation operated according to a special program, anticipating its periodical switching on.

On the day of launching — November 1st 1962, the Earth, and alongside with it the "MARS-1" probe, crossed the meteor stream "Taurides". 60 meteor particle impacts were registered during 100 minutes of flight at distances from 6 600 to 42 000 km. Their mass ranged to 10^{-7} g and more. The mean impact frequency constituted $7 \cdot 10^{-3}\ m^{-2}\ sec^{-1}$, taking into account the correction for the angle of stream encounter with the receieving surface. Since for sporadic meteor bodies the number of impacts of particles of indicated mass constitutes about $10^{-5}\,m^{-2}\,sec^{-1}$, we may estimate that all registered particles belong to the stream.

As may be seen from Fig. 2, the spatial density of meteoric bodies in the stream is extremely irregular. The particles moved in space by separate bunches observed at distances from 4000 to 45 000 km from one another. The measured spatial density of meteoric bodies averaged by accumulation time (2 minutes) oscillated within the $5.4 \div 0.35\ 10^{-6}\,m^{-3}$ range, i.e. a single meteoric body in a cube with a 60 — 140 m edge. No impacts were registered during the last 52 minutes of the 100-minute observation session (over a probe path extension of about 100 000 km relative to meteoric particle swarm).

No impacts were registered in the second half of November and in December at a distance to 23 million km from the Earth in the course of observations, each lasting no longer than 1 — 2 hours, and constituting in the aggregate 7 hours 32 minutes 26 seconds. In other words, it can be assumed that the data on the quantity of sporadic meteor bodies with masses of 10^{-7} g and more (for $m \geqslant 10^{-7}$ g, $N \approx 10^{-5}$ impacts $\cdot\, m^{-2} sec^{-1}$), obtained for the Earth' orbit environment (according to observations at a distance of thousands of kilometers from the Earth), remain valid also for these distances from the Sun.

From December 31, 1962 to January 30, 1963, the "MARS-1" probe registered again an increased density of meteor matter in the interplanetary space, at distances from 23 to 45 million km from Earth. 104 impacts were registered for an aggregate time of 4 hrs 13 min. 30 sec. Apparently the station met with a meteor stream so far not identified with any of meteor streams known on Earth. It is quite likely that it has an orbit not intersecting with the Earth's orbit.

The possible directions of stream's flow may be determined if one bears in mind that a surface sensitive to meteoric particle impacts was disposed at the reverse side of solar batteries while the latter were directed at the Sun. Inasmuch as the velocity of the meteor stream is unknown, the minimum and the maximum value of its velocity will be estimated on the basis of the fact that it belongs to our solar system. The stream's maximum velocity will be determined from the value of its parabolic velocity, about equal to 39 km sec^{-1}. The stream's minimum velocity may be computed if we consider it as moving along an elliptical orbit with an aphelion close to the point of its meeting with the interplanetary probe and with a perihelion near the Sun. The latter's value may be taken equal to about 0.03 — 0.1 a. e., originating from the fusion temperature of hardly-fusible meteor particles, and considering that at lesser distances from the Sun the hard particles are not preserved , the stream's v_{min} will be near 6 km/sec. With such an estimate for v_{max} and v_{min} the flux velocity directions are included in an angle of about 200° opposite to the Sun. As may be seen, the possible directions of the stream and the angle of meteor bodies' encounter with a surface sensitive to them vary within broad limits. At the same time the magnitude of the effective surface will vary by almost ten times if we exclude the rebounding at impact. The mean impact frequency N for the case of normal particle incidence upon the surface constitutes $4.5 \cdot 10^{-3} m^{-2} sec^{-1}$, and at oblique incidence $N_1 = N \sec \theta$, where θ is the angle of incidence.

The spatial density of meteoric bodies in this stream was also as irregular as in the Taurides (fig . 3). Assigning ourselves the maximum possible relative velocity of the meteor stream and the corresponding angle of encounter with the receiving surface, we shall obtain an estimate of the spatial density of meteoric particles averaged by the time of impact accumulation. It is equal to $1.7 \cdot 10^{-6} \div 6.7 \cdot 10^{-4} m^{-3}$, i. e. one meteoric body in a cube with a 40 — 80 m. edge. At the same time the distances between bunches encountered in the probe's path were from 8 000 to 190 000 km.

As may be seen, this meteor stream is analogus to Taurides at least in its mean spatial density and matter distribution in the stream.

After January 30, 1963 the instrumentation for meteoric particle registration ceased to operate. It is therefore not known how long the motion of the "MARS-1" probe continued in a medium with increased spatial density of meteoric bodies.

The investigation of meteor matter beyond the limits of the terrestrial orbit, just completed with the help of the instrumentation aboard the automatic interplanetary station "MARS-1" for the first time, constitutes besides its scientific value, a purely practical attainment. A large number of meteor streams, unknown on Earth, exist in the interplanetary space. Space probes directed toward remote planets may possibly encounter them. Regular investigations of the interplanetary space will provide the possibility to study well the future space routes also from the standpoint of meteoric danger.

In conclusion the authors are deeply grateful to A. A. Lykova, M. V. Leonova and V. V. Malikov for their active participation in the work and to A. K. Platonov for participating in the processing and interpretation of the results.

**** THE END ****

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[No references, but Figures follow in annex]

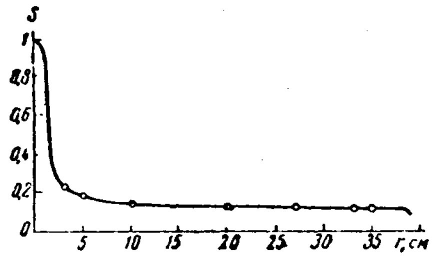

Fig. 1. Characteristic of pickup sensitivity.

S — relative sensitivity of the pickup,
r — distance from its center.

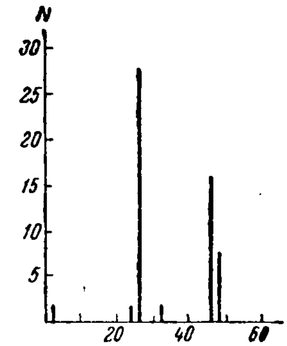

Fig. 2. Data for the 100-minute session of 1 Nov. 1962.

Observations in the Taurides stream.

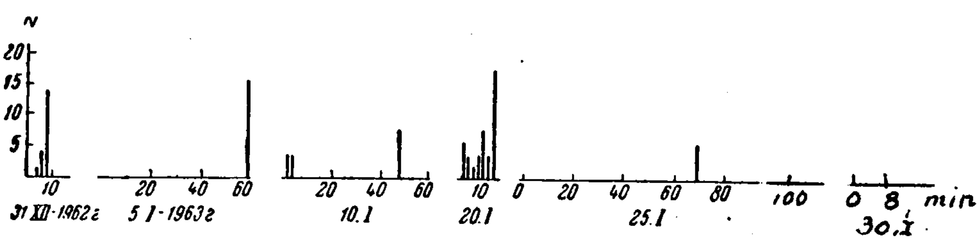

Fig. 3. — Observation data for the time as of 31 Dec. 1962

The duration of sessions is plotted in the abscissa

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